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NOTES ON THE LIFE CYCLE OF TWO SPECIES OF ACANTHOCEPHALA FROM FRESHWATER FISHES *

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The complete life cycle is not known for a single typically North American species of Acanthocephala. Species which have served as the basis of work by investigators on other continents have invariably revealed a complicated cycle of development involving at least one other host in addition to the definitive host which shelters the mature worms. Frequently intermediate hosts have been found intercalated between the primary and the definitive hosts. In most species of Acanthocephala there is not an absolutely fixed specificity of hosts, either primary or definitive. Consequently it is probable that species for which the life cycle has been determined in another country may have acquired entirely different species of hosts on this continent. For example, *Gigantorhynchus hirudinaceus* (Pallas), the common acanthocephalon of the hog, has an extremely broad geographical distribution, but it must utilize various primary hosts within the limits of its range for the geographical distribution of the insect larvae which serve as primary hosts in any given locality does not coincide with the geographical distribution of the parasite. Thus Stiles (1892) found that the species of insect larvae which act as primary hosts for this parasite on this continent are entirely different from the ones that are utilized in its European habitat. For similar reasons one could not be justified in assuming that representatives of the species *Echinorhynchus gadi* Müller from fishes of our Atlantic coast undergo a development identical in detail with representatives of the same species from the European continent.

The works of Linton are the only published records which include information concerning larvae of Acanthocephala peculiar to North America. His references are based chiefly upon incidental observations of larvae found in marine fishes. His frequent mention of *Echinorhynchus incrassatus* from the viscera of various species of marine fishes (1891, 1901, 1905) unquestionably refers to the larvae of an undetermined species of Corynosoma as evidenced by his own drawings. He also recorded the occurrence of *"Echinorhynchus proteus"* (1901 : 481) in the mesentery of a flounder. This last may without doubt be referred to the genus Pomphorhynchus, though the specific identity with the European *P. laevis* (= *"proteus"*) is to be doubted. Thus two of the larval parasites mentioned in Linton's works stand without any definite relationships to species known to occur as adults in the North American fauna. In addition to the above mentioned records, Linton described (1889) a new species of Acanthocephala, *Echinogaster sagittifer,* from larvae which were encysted in the viscera of marine fishes. At a later date he definitely associated these larval forms with adults which were subsequently discovered. The larvae from which the species was described were in an advanced stage of development, ready to infect the definitive host. Consequently even in this instance of a marine species of Acanthocephala peculiar to the North American continent little is known of the details of its life cycle. Yet this represents as full an account as is to be found in literature, while for the purely freshwater species nothing has been recorded. In no instance has a complete life cycle been outlined and verified by data from experimental infestation of either primary or definitive host.

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In the course of extensive laboratory and field investigation upon Acanthocephala, the writer has come into possession of facts relating to the life cycle of two species of these parasite from freshwater fishes. In view of the fact that no data concerning such forms is available in the literature, it seems advisable to publish the results of this investigation in the hope that other investigators may be induced to cooperate in bringing together data bearing upon the development of other species of these parasites. The present paper embodies information relating to certain phases in the life cycle of two species belonging to the genus Echinorhynchus, both of which are apparently peculiar to freshwater fishes of North America.

SOURCES OF DATA

Investigators in specialized fields frequently fail to realize the service they might render to other investigators by making known to them the incidental or accidental information that they may acquire in the pursuit of their special problems. The materials which formed the basis for the present study have in great measure come to the writer through the cooperation of friends who secured the data while carrying on investigations directed along fundamentally different lines. I am under especial obligation to Drs. A. S. Pearse, A. R. Cooper, G. R. La Rue and Director A. F. Shira for specimens and for data concerning the occurrence of larval Acanthocephala. The U. S. Bureau of Fisheries during the summer of 1919 extended to the writer the opportunity of carrying on investigations concerning the life histories of Acanthocephala infesting fishes, but that work has not progressed to a stage where positive data are available from the experiments that were undertaken.

THE LARVA OF *ECHINORHYNCHUS COREGONI* LINKINS

In the course of investigation upon parasites of fishes, Dr. A. R. Cooper encountered heavy infestations of Acanthocephala in the digestive tract of whitefish taken from the Great Lakes region, especially from the Canadian shore of Lake Ontario. The same individuals which bore heavy infestations of these parasites contained numerous amphipods (*Pontoporea hoyi*) in their stomachs. An examination of some of the amphipods revealed the presence of larval Acanthocephala, which, according to unpublished observations by Dr. Cooper, were located in the body cavity. I have examined specimens, both from the body cavities of these amphipods and from the intestine and ceca of the fishes, and have identified them as belonging to the species *Echinorhynchus coregoni* Linkins. The larval forms taken from the bodies of the amphipods were in a late stage of development. In fact, the size and plan of organization of these larvae did not in any manner differ from the juvenile representatives of the same species taken from the intestine and ceca of the definitive host. All of the larvae which I examined had the proboscis fully retracted within the body, so that serial sections were necessary for accurate determination.

Early stages in the development of this species, from the time the embryo leaves the body cavity of the gravid female to the infecting stage, remain unknown. It seems probable that the entire larval existence may be passed in the body of an amphipod which serves as primary host, and that the larva is introduced into its definitive host when some fish, suitable as a definitive host, devours the infected amphipod.

THE LIFE CYCLE OF *ECHINORHYNCHUS THECATUS* LINTON

A number of years ago Director A. F. Shira of the Fairport, Iowa, Biological Station, encountered larval Acanthocephala in amphipods (*Hyalella knickerbockeri*) which he was rearing as food for young small-mouthed black bass at the Homer (Minnesota) station of the U. S. Bureau of Fisheries. The appearance of these larvae in the amphipods was coincident with an outbreak of an epidemic of acanthocephalan infestation among the young bass. Specimens of the parasites, both from the alimentary canal of the fish and from the bodies of the amphipods, were preserved. Through the courtesy of Director Shira, I have been permitted to examine a few of these specimens and have determined that the mature worms from the bass and the larvae from the amphipods both belong to the species *Echinorhynchus thecatus* Linton. The demonstration, in this instance, of the occurrence of larvae of *E. thecatus* in amphipods and the general infestation of the young bass which were being fed these same amphipods under controlled conditions lends strong support in advocacy of the contention that *E. thecatus* may undergo its complete cycle of larval development within the body of an amphipod and reaches maturity when a suitable definitive host devours the amphipod which shelters the infecting stage of the larval parasite.

Data from other sources furnish incontestable evidence that one or more intermediate hosts may be intercalated between the primary and the definitive hosts of *Echinorhynchus thecatus.* Larvae which unmistakably belong to this species have been encountered frequently encysted in the viscera of various fresh water fishes. At the present time no proof of the method by which they come into this host is available. However, it seems probable that they enter in the same manner as found in other species of these parasites. If an amphipod bearing young larvae of *E. thecatus* is eaten by a fish the young larvae would be liberated in the digestive tract of the fish, but being imperfectly developed would not be able to maintain themselves as intestinal parasites of the new host. Such early larvae probably penetrate the wall of the digestive tract of their new host and become encysted in the mesenteries, in the peritoneum, or in the organs lying in the general body cavity. Here they continue development until they reach a stage identical with the fully formed infecting larvae that occurs in the amphipod.

Evidence in support of the above outlined stage in the life cycle of *E. thecatus* has been derived from the study of material collected by Dr. A. S. Pearse who encountered numerous cysts of various size in the peritoneum of the yellow perch. Pieces of the peritoneum containing these cysts were stained and mounted for study. Many of the cysts included numerous hooks (Fig. 2) which were directly recognizable as the proboscis hooks of *E. thecatus,* while others, more fully developed, contained complete larvae (Fig. 3) in the infecting stage. The writer expects at some later date to examine the living cysts and to supplement the present study by an examination of serial sections of these encysted larvae.

The smallest cyst in the material examined which has been definitely recognized as containing a larva of *E. thecatus* is 0.18 mm. in diameter and almost spherical in form (Fig. 2). A definite fibrous wall surrounded this cyst, and others of a similar structure. In the cyst shown in this figure no definite arrangement of the hooks could be observed, though in many of the more advanced stages the inverted proboscis could be definitely recognized in the toto-mounts of the cysts.

In many of the largest specimens, which frequently attained a length of approximately 2 mm., the proboscis of the larva was fully extended as shown in Figure 3. Individuals such as the one shown in this figure represent the end of the developmental processes of the larva, for they have attained the full size and the same organization of the body as found in the juvenile specimens of the same species removed from the lumen of the intestine of a definitive host (see Fig. 4).

It is significant that fully formed larvae of the infesting stage are found in Hyalella, while much smaller, less fully developed specimens have been observed in a vertebrate which serves as an intermediate host. This would indicate that the intermediate host in this instance serves not only as a repository for larvae which accidentally enter its body, but also furnishes suitable conditions for completion of the development of the immature larvae which has not gone far on its course when its sheltering primary host is eaten by the intermediate host.

Attainment of the adult body form from a juvenile, such as shown in Figure 4, involves practically no change in the proboscis. Simple increase in size of the body proper and development of the reproductive organs from the rudiments present in the larva constitute the chief developmental processes that proceed after the larva has entered the digestive tract of its definitive host. Since many of the characters utilized in the classification of the Acanthocephala are associated with the proboscis, the early development of this organ renders an identification of larvae possible even though the general body form may be grotesquely different from that of the adult.

The writer (1919) has previously discussed the occurrence of larvae of *E. thecatus* in the viscera of fishes from Douglas Lake, Michigan. Larvae of this species from various organs of fishes examined by Dr. G. R. La Rue are identical in structure with the juvenile forms of the same species which were taken from the digestive tract of definitive hosts from the same locality.

Stages in the development of *E. thecatus* earlier than the one shown in Figure 2 have not been discovered. The form of the larva from the time it leaves the body of the gravid female parasite (Fig. 1) until it reaches this comparatively late stage in its cycle remains unknown.

SUMMARY

1. Some phases in the life cycle of *Echinorhynchus coregoni* Linkins and of *E. thecatus* Linton have been made available, chiefly through the cooperation of other investigators.

2. Larvae of *E. coregoni* have been found in *Pontoporea hoyi*.

3. Pontoporea containing these larvae were taken from the stomach of whitefish which carried an infestation of this some parasite in the digestive tract.

4. Larvae of *E. thecatus* have been found in *Hyalella knickerbockeri*. The young bass fed on these amphipods acquired a general infestation of *E. thecatus*.

5. Various fishes harbor encysted larvae of *E. thecatus* in their viscera and in the peritoneum. An intermediate host does not seem essential for the completion of the life cycle of this parasite.

6. In these two species the transformation from fully formed larva to the adult involves conspicuous changes in the body proper, but practically none in the proboscis.

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EXPLANATION OF PLATE XIV

Stages in the life-cycle of *E. thecatus*

All figures were drawn with the aid of a camera-lucida from permanent, stained toto-mounts in balsam. Scales accompanying Figures 1 and 2 have the value of 0.05 mm., the others have the value of 0.1 mm.

Fig. 1.—Hard shelled embryo from body cavity of gravid female. Embryos are discharged in about this stage. Cleavage has progressed to a considerable extent.

Fig. 2.—Young larval cyst from peritoneum of yellow perch.

Fig. 3.—Late larval stage ready to infect definitive host. Larva embedded in peritoneum of yellow perch.

Fig. 4.—Juvenile form removed from intestinal cavity of yellow perch. This and foregoing figure drawn to the same scale show identity of form in late larva and juvenile from definitive host.

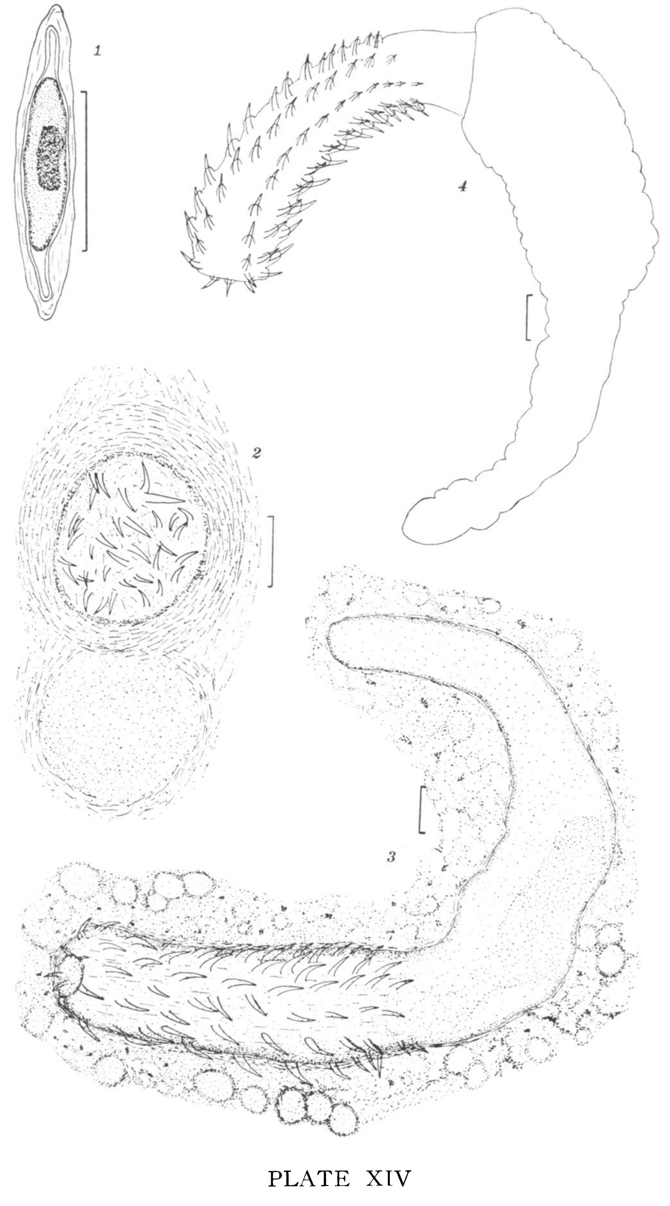

PLATE XIV